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ABSTRACT

Presented are abstracts and abstractors' analyses of seven studies related to science instruction and mathematics and three studies related to achievement. Analyses in the area of instruction are on studies of: teacher interventions in elementary science laboratory groups; variables accounting for success in an undergraduate science education course; the extended discretion approach to high school biology investigations; diagnostic-prescriptive teaching; the effects of the use of hand-held calculators; the effects of process instruction on problem identification skills; and the effects of Piagetian level on solving proportionality problems. Analyses related to achievement are on studies of: the prediction of achievement and success in an audiotutorial (AT) biology program; the effects of the components of logical reasoning on physics achievement; and differences in achievement of inner city students. Responses by two authors to analyses of their studies are included. (JN)

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SCIENCE EDUCATION

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NOTES FROM THE EDITOR:

This issue marks the tenth year of publication of Investigations in Science Education (it really doesn't seem that long!), It also marks a change in associate editors. Stan Helgeson is returning to the associate editor position, leaving Vic Mayer free to pursue other activities. Our thanks and appreciation go to Vic for helping with the production of the past several volumes of ISE.

Issue 1 of Volume 10 contains critiques of articles dealing with two topics: instruction and achievement. Also included are responses to two articles critiqued in this issue: McDuffie's response to Linda DeTure and the response of Volk and Hungerford to a critique by Lowell Bethel.

"Instruction" articles relate to teacher interventions in elementary science laboratory groups (Oakley and Crocker), variables accounting for success in an undergraduate science education course (Gabel and Sherwood), the extended discretion approach to high school biology investigations (Leonard et al.), diagnostic-prescriptive teaching (Long et al.), the effects of the use of hand-held calculators (Standifer and Maples), the effects of process instruction on problem identification skills (Volk and Hungerford), and the effects of Piagetian level on solving proportionality problems (Lawson and Wollman). "Achievement" articles are focused on the prediction of achievement and success in an AT biology program (McDuffie and Bruce), the effects of the components of logical reasoning on physics achievement (Enyart et al.), and differences in achievement of innercity students (Douglass et al.).

Patricia E. Blosser
Editor

Stanley L. Helgeson
Associate Editor

INSTRUCTION
AND
ACHIEVEMENT

Oakley, Wayne and Robert Crocker. "An Exploratory Study of Teacher Interventions in Elementary Science Laboratory Groups." Journal of Research in Science Teaching, 17 (5): 407-418, 1980.

Descriptors--Classroom Observation Techniques; Elementary Education; *Elementary School Science; *Group Behavior; Inquiry; Science Education; *Science Instruction; *Teacher Behavior

Expanded abstract and analysis prepared especially for I.S.E. by William R. Brown, Old Dominion University.

Purpose

Does the role of the teacher, especially as it relates to control of pupil activities, change with group structure? The investigators hypothesize that teacher and pupil roles in science lessons, particularly during teacher interventions, may not undergo the major change that would correspond to weakened framing (teacher expands the range of behavior options available to pupils) or to a redefinition of the classroom behavior setting.

Rationale

A stated goal of many of the course content improvement projects has been to increase pupil independence. Numerous strategies have been suggested such as use of small groups, increased hands-on experiences, and others to facilitate these "new" programs. The investigators suspect these obvious shifts in surface structures are insufficient to bring about the type of role changes of teachers required for increasing pupil independence. More comprehensive changes in the total school "system" may be necessary to effect long-term change.

The idea of ecological psychology and strong and weak framing of pedagogical processes are cited (Baker, 1968 and Bernstein, 1971).

Design and Procedure

Three levels of the variate correspond to teacher-class, pupil-pupil and intervention subsettings. Whole class communication was predominant

in the teacher-class setting. The pupil-pupil setting was characterized by lack of direct teacher involvement. An intervention was defined as occurring whenever the teacher or one of the pupils initiated communication which did not involve the rest of the class. If the presence of the teacher is critical to the role adopted by the pupils, then pupil-pupil interactions should differ from those in the teacher-class or intervention situations.

The criterion variables were six categories of teacher and pupil behaviors (Bellack, 1966). Major categories were structuring, soliciting, responding, or reacting.

The design does not "fit" the standard Campbell and Stanley nomenclature. The design can be described as a repeated measures design in which subjects were observed under three different "treatments" corresponding to the three levels of the variate.

Data were collected from 19 pupil pairs in three schools, grades three through six. A single lesson was video-taped focusing on a randomly selected pupil pair. All data coding was done from transcripts of the recordings.

Construct validity of the instrument used to code the criterion variables was established.

It is evident that the study was conducted as an exploratory exercise.

Findings

Interventions ranged from one to sixty-three sentences in length with a mean of 7.4. The mean number of interventions involving the teacher and a single pupil pair was 7.9. Teachers and pupils accounted for almost exactly the same number of intervention initiations. For short teacher-initiated interventions, teacher requests outnumbered declaration statements as initiating moves. For short pupil-initiated

interventions, declarative openings occurred more than twice as often as requests. The pattern of longer interventions was similar to that of shorter interventions. Many longer sessions ended with the teacher making a statement about procedures.

Interpretations

The investigators conclude that teacher and pupil roles are a function of certain general characteristics of the classroom as a behavior setting rather than of surface features. The stability of teacher behavior and the changes in pupil behavior across the subsettings suggest that the immediate presence of the teacher is a decisive factor in pupil roles but that the teacher role is determined by variables external to those found in these subsettings.

Two implications are discussed. Changes in teacher and pupil roles may be impossible to meet within the structure of any single curriculum project. Teachers need to analyze their role in detail rather than assuming that structural changes correspond to role changes.

ABSTRACTOR'S ANALYSIS

This exploratory study demonstrates what many course content improvement projects (CCIP) implementators have suspected --- long-term change of teacher and student roles is a total system effort. A science program that encourages problem solving has little likelihood of being successful in a school where all decisions are predetermined and printed in the rules and procedures memorandum from the central office. Problem solving skills have little pay-off on most system-wise standardized tests of achievement. Perhaps we need central-office personnel who are instructional leaders rather than managers of paperwork?

So much for wishful thinking! Although this study doesn't fit the mold of classical cause and effect research, it is valuable in pointing

to avenues of additional research. The classroom as a social system, broad-based teaching strategies to implement specific types of learnings, coordination of school systems to affect change, and implementation of CCIP as intended are a few broad areas of investigation.

A couple of minor comments may point toward improvements in reporting. The terms independent and dependent variables are inappropriate for an uncontrolled study. The expressions variate and criterion variable are appropriate.

Additional description of what actually occurred during the video-taped sessions would be helpful. It is implied, but not clearly stated, that students were working in a laboratory setting. It would seem reasonable that the type and length of interventions could be a function of the degree of activity and the preciseness of any printed materials such as direction.

Finally, the editor and referees of JRST should be commended for including this descriptive-explanatory manuscript along with the "usual" number-crunchers!

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Descriptors--College Science; *Educational Background; Elementary School Teachers; Higher Education; *Measures (Individuals); *Predictor Variables; *Preservice Teacher Education; *Science Curriculum; Science Education; Science Teachers; *Secondary School Science; Student Characteristics

Expanded abstract and analysis prepared especially for I.S.E. by James Reed Campbell, St. John's University.

Purpose

The purpose of this study was to determine what variables account for success in an undergraduate science education course (Basic Skills Science).

Rationale

One of the most difficult problems in science education is the reluctance of elementary school teachers to teach science in their self-contained classrooms. The authors of this study suggested the following set of interrelations:

Science and Math Courses taken in High School	Influence	Science Courses taken at the College level	Influence	Implementation of Hands-On Science Labs in Elementary School

This study examined the influence between the first two elements in the diagram. If this connection can be determined, it might lead to requiring more science and math courses at the high school and college levels for all preservice elementary school teachers.

Research Design and Procedure

This study used a sample of 113 preservice elementary school teachers who were enrolled in a Basic Science Skills course (3 credits). The course consisted of a series of hands-on labs made up of activities from various elementary and secondary curricula (i.e., SAPA, SCIS, ESS, IPS, etc). The labs were designed so that these preservice teachers could gain experience using activities which were currently being used in the schools. This practical experience was provided so that similar lessons could be implemented when these students become practicing teachers.

The research design that was used for this study (Cook and Campbell, 1979) can be diagrammed as follows:

$$O_1 O_2 O_3 O_4 \quad X \quad O_5 O_6$$

The X represents the treatment - the one semester Basic Science Skills course.

The pretests included the following instruments:

O_1 - Demographic Questionnaire. This instrument was used to determine the number of math and science courses taken in high school and college, the sex of the subjects, their college year, and the grades they expected to teach when they reached the schools.

O_2 - Fractions and Decimals test.

O_3 - Mathematics Anxiety test.

O_4 - Proportional Reasoning test.

The post tests included:

O_5 - Content Achievement tests. The authors administered four tests

during the course. The tests included essay and multiple choice items (only the multiple choice items were used in the regression analyses).

O_6 - Lab Practical. This instrument involved selecting one of nine hypotheses and answering questions which required the subjects to tell how they would: (a) design a lab to test the hypothesis; (b) the identification of the variables; and (c) the preparation of the data into mathematical equation (if possible).

The inference underlying this test was that it closely resembled the skills that would be needed by an elementary school teacher in setting up a lab for the students.

The dependent variables were:

1. Content Achievement tests
2. Lab Practical

The independent variables were:

1. Fraction and Decimal test
2. Math Anxiety test
3. Proportional Reasoning test
4. Credit hours of college science courses taken
5. The number of science courses taken at the high school level
6. The number of math courses taken at the high school level
7. Sex of subjects
8. College year

These variables were used in two separate regression analyses. The first analysis used the content achievement tests as the dependent variable; the second analysis utilized the laboratory practical test as the dependent variable.

Findings

1. From the first regression analysis, three variables emerged as significant predictors: Fraction and Decimal test (.001), number of high school math courses (.001), Proportional Reasoning test (.006). The Fraction and Decimal test accounted for 29% of the variance (F=46.17), the number of math courses accounted for an additional 9% of the variance (F=15.95), and the Proportional Reasoning test accounted for another 6% of the variance (F=7.94).

2. For the second regression analysis, two variables emerged as significant:

   a. Number of high school science courses (.001), which accounted for 9% of the variance (F=11.58).
   b. Fractions and Decimals test (.005), accounted for another 7% of the variance (F=8.17).

Interpretations

The authors do urge caution for any causal interpretations, and yet the very title of the article leads the reader to the conclusion that high school science courses do make a difference. The authors qualify this difference to mean some element involved in the lab practical. The number of high school science courses were not found to be significant predictors of science achievement.

The one variable that was significant in both analyses was the Fraction and Decimals test. In the first analysis, two different math skills, together with the number of math courses, emerged as significant predictors. Thus a certain competence in mathematics was found in predicting students' science achievement.

ABSTRACTOR'S ANALYSIS

The topic of this study - High School Science Courses Do Make A Difference - has become a timely area. Within a short period of time, American education has received two poor performance reports. The Twentieth Century Fund Task Force (1983) and the National Commission on Excellence in Education (1983) have issued reports about the shortcomings of American education. The underproduction of the schools is being called an "Economic Sputnik" (Marcuccio, 1983). In both of these reports the key question revolves around what students are achieving - particularly in math and science. As an example, the reports cite a steady decline in science achievement, a 17-year decline in SAT scores, and long-term declines in all standardized achievement tests. The National Commission has issued a series of recommendations to arrest these trends. One key recommendation is to require three years of high school science and math for all students. The newly elected president of the National Science Teachers Association (Sigda, 1983) recommends four years of high school science and two and one-half to three hours of science per week for grades 4 to 6. All of these recommendations assume that high school science and math courses do increase the literacy of students - but do these courses make a difference? It is interesting to note that only one-third of the preservice teachers involved in this study took three or more high school science courses. The investigators report that the number of science and math courses taken in high school do make a difference in one or more of the outcomes of a college science education course. The study also suggests that there may be a connection between the number and focus of high school and college science and math courses and the actual implementation of science lessons by elementary school teachers.

The title of the article is off the mark, since the number of high school courses was not found to be related to the content achievement of the Basic Skills course. In fact, the authors found that their sample retained fewer facts and concepts from their junior and senior high school science courses than expected. (There was no significant relation.)

The report itself was very precise and to the point. I have always admired such brevity but short articles invariably do not contain sufficient information for the scholar. Fortunately, the authors had published a more lengthy article about a previous study with the same course (Sherwood, Gabel, 1980). The two studies complemented one another and helped the reviewer get a more comprehensive idea of the research. One obvious strength of this approach enables researchers to improve their design and fine tune their instrument. Both improvements were evident from the reports. The authors eliminated instruments which contributed little to their analysis, and introduced a lab practical test which proved to be an important instrument in the current study.

One weakness of the article was the limited bibliography which did not contain several articles and research reports that were related to the topic. One reference (Chronicle of Higher Education) was a secondary source that simply mentioned one of the findings of the National Survey conducted by Weiss (1978). The National Science Foundation sponsored this project and has published a lengthy report about it together with reports from six other studies that were all related to the topic of this research study. The one item mentioned by the authors was that 16% of the elementary school teachers surveyed reported that they were unprepared to teach science. However, much more data were included in these reports which could have been used in this research study. As an example, the National Survey reported that 60% of their sample felt adequately qualified and 22% felt very qualified to teach science at the elementary level. The total amount of time these teachers devoted to science instruction averaged out to 19 minutes per day for the K-3 sample and 32 minutes per day for the 4-6 sample. In the NSF case studies (Stake and Easley, 1978) it was found that the amount of time devoted to science was frequently just reading in science and not the type of hands-on labs that the authors were training their prospective teachers to use.

The authors supplied reliability data for four of the six instruments used in this study. The Mathematical Anxiety test and the Proportional Reasoning test were developed by other researchers. The demographic questionnaire and the Lab Practical were developed specifically for this

study. However, no reliability data were supplied for either instrument. The demographic questionnaire apparently contained very few items. The question arises as to why more items were not added that could have supplied usable information. For example, why not ask these preservice teachers to give more information about each of their high school science courses? Were courses taught in a text dominated manner (Stake and Easley, 1978), or were they taught from an inquiry orientation? Did each course require labs? If so, were the labs the cookbook type or were they more process oriented? Similarly, it might be useful to find out if any of these prospective teachers experiences any hands-on science in their elementary and junior high school classes. What was their science instruction at these levels? Was it just reading about science? Finally, it might be useful to determine if each of the high school science courses was selected as electives or if they were required. Such data could have helped in analyzing the results. For example, is there a relationship between a preservice teacher's experience with hands-on labs and his/her ability to function in a college lab? Would individuals with such experiences score well on the Lab Practical?

Similarly, if a high school student selected several elective science courses, wouldn't this indicate an interest or underlying competence in the subject? Wouldn't such a competence surface in one or more of the dependent variables?

The most interesting instrument used in this study was the Lab Practical, although it is uncertain just what this test measures. The authors suggest that this test measures the students' ability to adapt materials to a hypothesis testing lab. This is a very pragmatic task that would be needed if an elementary teacher were to use hands-on process type labs. When the data from the Lab Practical were used as a dependent variable, it was shown that the number of high school courses the students had taken emerged as a significant predictor. But what did these courses contribute to this laboratory task? Certainly, it is not the science content contained in these high school courses. Perhaps this test measures something like "how to proceed like a scientist?" If the authors are to continue utilizing this instrument with their

research, they might administer it to one group of experienced elementary school teachers who are implementing "hands-on" science labs and also to another group of elementary school teachers who do not use such lessons. If the Lab Practical turns up a difference between these two groups, it would show that the instrument is measuring skills needed to run hands-on labs. This type of predictive validity would strengthen the use of the instrument with preservice teachers.

Another question about this study is why the authors did not use any of the variables most commonly used in predicting success in college science courses. Other researchers have used scores from the Scholastic Aptitude Test, high school and college grades, and overall G.P.A. (see Champagne, Klopfer, 1982).

One important area which was not represented in this study was the affective area. Prospective teachers' attitudes and fears about science would seem to be important variables to include in any analysis. The authors did use the Moore (1973) Attitude Scale Toward Science in their earlier study, but found it too insensitive to measure any growth over the course of a semester. Despite this fact, the authors should continue to search for affective instruments which could pin down just what their preservice teachers have retained from their high school courses. This information could be used to supplement the significant finding that was found on the Lab Practical.

The statistical technique used in this study was regression analysis, which represents the current state-of-the-art. The authors used eight variables for 113 subjects. This means that more than 10 subjects per variable were used for the regression analysis. This practice assured a sufficient number of subjects and is a strength for the study.

The authors did not mention the software package that they used, however this information should be supplied in any report. One set of data which was not presented was a table of intercorrelations among all the variables. Such data are used in regression computer programs and are helpful in any analysis of the data. As an example, we could expect

substantial correlation among four of the variables. The number of math courses taken probably correlated with high scores on the Fractions and Decimal test and on the Proportional Reasoning test. All of these variables could be expected to be negatively correlated with math anxiety. In any regression study, the optimum would be to use variables with as little overlapping as possible. The more common variance the variables have, the more difficult it is to isolate significant variables.

In terms of research design, the one group pre-post test design is not considered a strong research design (Cook, Campbell, 1979). However, for this sample it does not seem feasible to have a control group since this would mean depriving a sample of preservice teachers an important experience. Perhaps the Cook-Campbell Cohort Partitioning design could help solve the problem. When a researcher is forced to use the group design, Popham (1975) has suggested examining alternative hypotheses. One such hypothesis could have been that students who take more high school science and math courses are just more competent in these areas. If this were so, they would be expected to have more success in college courses where the same set of skills were being utilized. If the authors had collected data like the students' G.P.A.s, they might have been able to analyze such an alternative hypothesis. In the final analysis, it would have strengthened the study to select the best of several alternative hypotheses.

In summary, the study analyzed in this report could be used to support the requiring of more high school math and science courses - particularly for prospective elementary school teachers. If the authors of this research can continue to refine their instruments and isolate variables which are found to relate both to college course outcomes and to the skills needed in implementing science in elementary school classrooms, they will have made an important contribution.

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Leonard, William H., Gordon R. Cavana and Lawrence F. Lowery. "An Experimental Test of an Extended Discretion Approach for High School Biology Investigations." Journal of Research in Science Teaching, 18 (6): 497-504, 1981.

Descriptors--*Biology; *Curriculum Evaluation; Grade 10; High School Students; *Science Activities; Science Course Improvement Projects; *Science Curriculum; Science Education; *Science Instruction; Secondary Education; *Secondary School Science; Teaching Methods

Expanded abstract and analysis prepared especially for I.S.E. by Constance M. Perry, University of Maine at Orono.

Purpose

The investigators' purpose was to see if students can learn laboratory concepts under conditions of relatively high discretionary demand and if increased discretionary demands will produce greater academic achievement. Discretion was defined as the exercise of independent judgment. The stated hypotheses were:

1. When high school biology students are required to learn laboratory concepts under increased discretionary demands, the students will perform at least as well on laboratory reports and quizzes as a comparable group of students who learn laboratory concepts using BSCS Green Version laboratory investigations.
2. After using the Extended Discretion investigations, the biology teachers would indicate a preference for using the new approach over their previously used BSCS Green Version investigations.

Rationale

The research was based on the belief that discretion--the exercise of independent judgment--is a part of most educational pursuits and is encompassed in educational goals such as: the development of autonomy, the wise use of resources, and the ability to make rational decisions. Another underlying belief was that student use of discretion is necessary to successfully conduct many high school biology laboratory investigations and in addition, that discretionary demands placed upon biology students by commercially prepared laboratory investigations could be much greater

(Butts, 1963; Schwab, 1964; Herron, 1971; Egleston, 1973). The study followed an exploratory study which recognized the importance of discretion in learning and observed that existing science activities in an urban high school were quite directive (Cavana, 1971).

Procedures and Research Design

Sample: Five secondary teachers trained to carry out extended discretion laboratory activities, which provide students extensive opportunities to plan their own lab procedures; each taught two classes of biology students at suburban Piedmont Hills High School in San Jose, California. Each teacher had an experimental and one comparison group. Students were randomly assigned to each teacher and again to either the experimental or comparison class.

Design: A randomized posttest only, control group design was used. The independent variable was the method of laboratory instruction for the entire school year. The dependent variables consisted of: (1) teacher generated scores on 26 laboratory reports for each student; (2) scores of 11 teacher constructed quizzes of laboratory concepts; (3) and scores on a teacher questionnaire for preference of each experimental versus comparison lab activity.

The new laboratory approach had three differences from existing BSCS Green Version labs.

1. The student was given a written statement containing: (a) an overall goal, (b) one to three task statements, (c) a place for teacher initial after a review of each task, (d) a list of available equipment and resources.

2. There was little recipe-like procedure to follow.

3. The student was asked to be as independent of the teacher as possible, and the teacher attempted to withhold procedural information except during a scheduled review of a given test.

Minimum discretionary demand is the shortest period of time a student is permitted to work before he/she is allowed a review of his/her work by the teacher. Overall differences in discretionary demand between the two approaches were significant beyond 0.005 (t value of 3.46). Also a comparison between frequencies of various teacher-student interaction categories after Flanders (1970) was done while the study was being conducted. A X^2 analysis showed significant differences between the two approaches with respect to teacher-student interaction. These two findings were used to argue that the two laboratory teaching approaches were measurably and significantly different (Leonard and Lowery, 1979).

Instruments: All students regardless of which group (experimental or comparison) completed 26 lab reports and 11 teacher constructed laboratory concept quizzes. In addition, teacher preference data were collected after each pair (experimental and comparison) of laboratory investigations were taught. Teachers assigned a numerical score to each experimental laboratory investigation according to how they believed the lab attained the instructional objectives in comparison to the other laboratory investigation (comparison group). The numerical scores were:

5 = much better than comparison lab
4 = somewhat better than comparison lab
3 = about equal to comparison lab
2 = somewhat worse than comparison lab
1 = much worse than comparison lab

Data Analysis

T-analysis was used between teacher graded laboratory report scores of experimental and comparison classes over the school year and also between quiz scores of the two groups. For the teacher evaluation of the extended discretion lab investigations on a scale from 1-5, the comparison investigations were arbitrarily assigned a value of 3.0. Then the data were treated to t-analysis.

Findings

Laboratory Report Scores: Differences were significant in favor of the experimental group for three of five teachers two at p 0.05 and one $p < 0.01$. None of the classes with increased discretionary demands did poorer than their respective comparison classes. Experimental hypothesis one with respect to lab report scores was accepted.

Laboratory Concept Quiz Scores: Differences were significant in favor of the experimental group for three of the five teachers ($p < 0.01$), and overall differences favored the experimental treatment ($p < 0.01$. One teacher's (teacher B) comparison class scored significantly higher ($p < 0.01$) than the experimental group and there was no difference between the two groups of teacher C. The experimental hypothesis one with respect to quiz scores was accepted.

Teacher evaluation of extended discretion labs: Differences were significant in favor of the discretion investigations for four of the five teachers (one at $p < 0.05$ and three at $p < 0.01$). Teacher A's preference for the discretion lab investigations was not significant. These data show a teacher preference for the discretion lab approach so far as the student attainment of instructional objectives is concerned. (It was in this light only that they were to compare the labs.)

Interpretations

This study showed that students can handle increased discretionary demands and when students learn under increased demands their acquisition of laboratory concepts is improved. A goal statement, a few task statements systematically reviewed by the teacher, and a list of resources were sufficient for students to attain goals of a lab investigation similar to those of the BSCS Green Version.

The Extended Discretion approach is a means of individualization. It allows students to select procedural options and allows the flexibility of discretionary reviews when and if needed.

It appears that tenth-grade biology students, if given training and opportunity, are able to use discretion to a greater extent with greater rewards than is typically allowed. Students were able to learn on their own discretion for periods of 10-15 minutes at the beginning of the program and for at least three class periods later.

ABSTRACTOR'S ANALYSIS

Many studies have been carried out in the last two decades and before, comparing "traditional" and discovery or inquiry modes of science instruction. The results are conflicting. Leonard, Lowery and Cavanna are dealing with the same theme but in a slightly different manner. Rather than comparing two modes of instruction in total, they have narrowed in on what they call discretion - the exercise of independent judgment. After observing that existing science activities in an urban high school were quite directive (Cavana, 1971), they set out to see if students could learn under conditions requiring more discretion and also if such conditions would produce higher achievement. Their study adds to the knowledge base in science instruction and provides an impetus for further research.

It was relatively easy to follow how the researchers proceeded in their study. The problem was significant and clearly written, with important terms defined. The randomized posttest only, control group design was well chosen. The randomization omitted the need for a pretest and the size of the sample appeared large enough to not warrant a check on equivalence of the two groups (Isaac and Michael, 1972), although giving the actual sample number, rather than just the number of classes would clarify that point. The statistics used were simple and appropriate.

The hypotheses were both stated in brief, clear terms; however, hypothesis two stating that the five biology teachers, after using the Extended Discretion investigations, would prefer that approach was somewhat

misleading. Later on it is stated that the teachers were to compare the labs and state a preference according to student attainment of instructional objectives only. Indeed, that is a very important factor in deciding preference, but other factors, such as teacher preparation time and amount of time for the completion of the lab, enter into deciding preference. By stating the preference criteria in the hypothesis, possible confusion could have been avoided.

In reporting the results, there appears to be two omissions. The first is in describing the t-analysis between teacher-graded laboratory report scores of experimental and comparison classes. It is stated that differences were significant in favor of the experimental group for three of five teachers but it is not stated that the overall effect is not significant. Yet in describing the t-analysis of quiz scores between the two groups where the overall effect is significant with the experimental group scoring higher, it is so stated. For the sake of consistency, both overall effects should be mentioned. The second omission is in reference to hypothesis two which deals with teacher preference. It is stated that the data show a distinct teacher preference for the Extended Discretion approach, from which one assumes the hypothesis is accepted, but unlike in the reporting of results for the first hypothesis, it is not stated.

Obviously much must be left out when a study is reported in a journal; nowever, it would have clarified the study if the authors had described briefly or showed examples of the laboratory reports and quizzes. Were the reports and quizzes objective measures which would allow for little teacher bias in their scoring or were they such that much room was available for an individual teacher to over or under estimate achievement? The answer to that question would have great bearing on the findings of the study.

Another important point which is not specifically mentioned is whether the experimental group and comparison group laboratory times were identical.

Perhaps the reader is to assume they were since it is stated in both groups the students spent approximately 50% of class time in labs, but the study reports the discretionary demand time to be much greater for the Extended Discretion investigations. If more time is spent in the exercise of independent judgment is more time also spent in laboratory for the experimental group; and, if so, is it the increase in discretion or the increase in time which resulted in greater achievement? If the times were identical, a simple statement to that effect would be appropriate. If the times in laboratory were not identical, that too should have been stated.

Assuming that the time spent in lab was equal for both groups and that the five teachers were unbiased in their scoring of reports and quizzes, the conclusions made are substantiated by the evidence presented. The authors make no generalization of results beyond tenth-grade biology students. Again, if the total N had been provided, one could better judge whether that generalization is appropriate. Also one must be cautious in generalizing beyond the population from which the sample was drawn. The sample came from a suburban high school. Whether rural or urban tenth-grade biology students would perform similarly is not known.

Withstanding the criticisms made of the study, the authors have succeeded in the important endeavor of getting students to exercise independent judgment, a process they can and will use not only in studying biology but throughout life.

Suggestions for Further Research

Several excellent recommendations for further study were made. Application of the approach at other grade levels and varied settings and studying the relationship between discretionary ability and other psychological factors were two of them. A couple other further studies could also be helpful in learning more about discretion in reference to teachers and students. The idea of preference should be expanded. Do the teachers prefer the extended discretion approach on other counts as well as for the attainment of student objectives? A related question

to that is, if teachers prefer the extended discretion approach, why is it not widely employed? A follow-up study with the same teachers would also be useful to ascertain whether it was the newness of the experimental approach which created the findings or whether the findings are stable over several years.

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Descriptors--*Academic Achievement; Aptitude Treatment Interaction; *Biology; *Diagnostic Teaching; High School Students; Locus of Control; Science Course Improvement Project; Science Education; *Science Instruction; Secondary Education; *Secondary School Science; *Student Attitudes; Teaching Methods

Expanded abstract and analysis prepared especially for I.S.E. by Chris A. Pouler.

Purpose

This study was intended to measure the effect of three variations in the use of diagnostic-prescriptive teaching on the cognitive and affective biology achievement of high school students. The variations included no diagnostic-prescriptive assistance, teacher-managed diagnosis and prescription and student-managed diagnosis and prescription. The answers to the following research questions were found.

1. What are the effects of differing types of diagnostic-prescriptive learning assistance on the biology achievement of students?
2. What are the effects of aptitude on the biology achievement of students?
3. What are the effects of locus of control perception on the biology achievement of students?
4. What are the effects of differing types of diagnostic-prescriptive learning assistance on the attitudes of high school biology students toward subject matter and instruction?

Rationale

Biology is a complex subject to teach. Does a way exist for students to learn better using a self-directed (student-managed diagnosis and prescription) approach? Previous research had indicated that students receiving maximum guidance learned and retained more.

Research Design and Procedure

Population: Ninety-three high school students in three BSCS classes were selected to comprise three groups: (a) the control, no diagnostic-prescriptive assistance, (b) teacher-managed diagnosis group, and (c) student-managed diagnosis and prescription group. Each group was stratified on measures of aptitude (high, middle and low) and locus of control.

Instruments: Three cognitive posttests and one 18-item Likert scale attitudinal questionnaire were utilized to measure the differences in group biology achievement and content attitudes.

Design: A 3 X 3 X 2 (treatment X aptitude X locus of control) factorial design with all factors fixed was employed to measure differences in group means and significant interactions.

Procedure: The study was conducted over a four week period using the BSCS green version. The following treatment conditions applied.

1. Control group--This group received lecture and laboratory instruction without benefit of diagnostic tests or prescribed remediation.
2. Teacher-managed diagnostic-prescriptive assistance-- Same lecture and lab activities as control except that progress checks were administered two or three times a week. Teacher informed students of their weaknesses and prescribed remediation.

3. Student-managed diagnostic-prescriptive assistance-- Same lecture and lab activities as control. Students had to administer their own progress checks and participate in remediation if they wished.

Findings

On each of the three cognitive tests there was a difference in the mean scores between the groups. The teacher-managed group scored higher than the other two. When the teacher-managed group was compared with the control, significant differences occurred in each instance. The only significant difference between the teacher-managed and student-managed groups occurred in the third test. As for the differences between the student-managed and the control groups, there is no significance although such a result was approaching significance. The mean scores were higher for the teacher-managed group and lowest for the control group for each cognitive test.

As for the attitudinal dimension of the study, there was a significant finding between the student-managed group and the other two. Along the same lines, internal locus of control students outscored their external counterparts in both the control and teacher-directed treatment groups but did less well than externals in the student-directed remedial group. This effect was significant.

Interpretation

The teacher-managed group outperformed the others. Yet there were no significant differences between this group and the student-managed one until the third test. Time is therefore a factor for student-managed instruction.

ABSTRACTOR'S ANALYSIS

On the surface the results appear to be quite predictable--the teacher-managed diagnosis and prescription group outperformed the others.

However, the difference was only significant for a short period of time. Therefore, a student-managed approach will provide worthwhile results over a brief unit of instruction. It is interesting to note that no significant differences occurred between either the student-managed or control groups. The cynic could easily conclude that this study proved that teacher-managed diagnosis and prescription is useful if employed over a long period of time.

Of further note is that students with internal locus of control outperformed their external locus of control counterparts in both the control and teacher-directed treatments but did less well than the externals in the student-directed remedial group. The F value associated with the main effect was significant, but the reported interactions made interpretations difficult.

The biology course curriculum was BSCS which is not always the easiest for non-traditional approaches. This study might be interesting to repeat with a different curriculum.

Overall, the findings justify the purpose. In an age where the trivial often becomes noteworthy, research must be carefully studied for its merits. This study provides insight that might be useful for planners of curriculum and future researchers. However, it is by no means definitive.

Standifer, Charles E. and Ernest G. Maples. "Achievement and Attitude of Third Grade Students Using Two Types of Calculators." School Science and Mathematics, 81 (7): 17-24, Jan. 1981.

Descriptors--*Academic Achievement; *Calculators; Elementary Education; Elementary School Mathematics; *Grade 3; *Mathematics Education; *Mathematics Instruction; *Student Attitudes

Expanded abstract and analysis prepared especially for I.S.E. by Paul Joslin, Drake University.

Purpose

Stated purpose was to evaluate the effectiveness of the supplemental use of two types of hand-held calculators with third grade students.

The study compared acquisition and retention of mathematical skills, and attitude towards mathematics of three groups of third graders all using the same instructional program. A control group used paper and pencil only and two experimental groups used hand-held electronic calculators; the other used a programmed feedback type that displays basic algorithms at random.

Rationale

Based upon reports of previous studies, the authors hypothesized that electronic calculator use by students would improve attitudes, enhance motivation, and increase achievement. These results appear to be related to or possibly caused by: 1) the immediate feedback given by calculators, and 2) intrinsic reinforcement of the activity of their use.

They also hypothesized that programmed-feedback calculators would produce greater gains in mathematical achievement than would four-function calculators because the former required a predicted answer based on a mental calculation. In contrast, the regular calculator requires no prior mental calculation.

Research Design and Procedure

Treatment Groups. Nine third grade classes were randomly selected in eleven schools in one school district. These groups were randomly assigned to one of three treatment groups. All groups used the regular mathematics program which emphasized the basic facts of the four operations: addition, subtraction, multiplication and division.

Control Group (N=64). Traditional methods employed. Students did all calculations and checking by paper-pencil methods.

Experimental Group I (N=77). Conventional four-function, hand-held calculators (Texas Instruments 1200) were used 8-10 minutes per day to: (1) check results of paper-pencil calculations, (2) drill on basic facts, and (3) perform supplementary calculator activities.

Experimental Group II (N=82). Programmed feedback calculators (Texas Instruments Little Professor) were used. These display algorithms at random and indicate whether a student's response is correct or incorrect. The calculators were used 8-10 minutes per day to: (1) practice basic facts, and (2) perform basic algorithms.

Sequence and Schedule
Instruments Used

The experiment was conducted during the Fall Semester of 15 weeks.

Pretests 2nd week of semester

1. For attitude: Dutton's Attitude Toward Arithmetic Scale
2. For achievement: SRA Assessment Survey-Primary II, Form E
3. For general ability: SRA Short Test of Educational Ability

Treatments 11 weeks, 5 days per week, approximately 50 minutes per day as previously described.

Post Tests 11th week. (Note: Treatments were apparently 9 weeks in length.)

1. For attitude: Same as pretest. (Identical form)
2. For achievement: Same as pretest but Form F.

Retention Tests 15th week, at end of semester.

1. For attitude: Same as pretest. (Identical form)
2. For achievement: Same as pretest. (Identical Form E)

Analysis Analysis of covariance was used with:

1. achievement and attitude pretest scores as covariates for achievement defined in terms of computational skills.
2. achievement and attitude pretest scores as covariates for attitude.

Four criterion variables were used. Significant differences were observed among groups on computational skills and total mathematical achievement. No significant differences among groups were observed on conceptual skill and attitude towards mathematics.

Comments. All methods used seem reasonable and appropriate: sample size, assignment to treatment groups, treatment variation and controls, length of treatment, tests used, schedule and sequence, and methods of analysis.

The effect of teacher variable must always be a concern in such experiments especially when the numbers are small, in this case 9. However, when the selection is random, and the population adequate, as in this case, it is not possible to fault stated findings.

An uncontrolled variable must be mentioned. The experimental groups apparently used some activities, that, while planned for these groups, could possibly have been made available to the control group but apparently were not.

Findings

The researchers reported results as follows:

At Post Test Time:

1. In computational skill regular computer group was superior to programmed computer group and both were superior to control group.
2. In general mathematical achievement regular computer group was superior to the other two groups.
3. There were no differences among groups in attitude and in conceptual skills.

At Retention Test Time:

1. In computational skill the regular computer group was superior to the other two groups.
2. In general mathematical achievement the regular computer group was superior to the other two groups.
3. There were no differences among groups in attitudes and in conceptual skills.

The investigators concluded that:

1. Daily use of regular hand-held calculators is more effective in promoting acquisition of computational skills and total mathematics achievement than use of programmed-feedback calculators or traditional paper-pencil calculations alone.
2. Basic design of the two types of calculators appears to have been more important than immediate feedback in determining the differences found between the two calculator groups.

ABSTRACTOR'S ANALYSIS

The interplay between student interest and motivation and the effects of these on achievement, however defined, whether in terms of knowledge and/or skills, or even attitudes, is of great interest to teachers and curriculum writers. Of current national concern is the belief, or perception, that the general level of mathematical competence in students and young adults is below a level needed for national economic and social health. Of special concern is apparent low interest in mathematics and math-related occupations by females. Any studies that can reveal and validate ways to improve interest, attitude, and achievement are indeed welcome.

Previous studies indicate that calculator use is intrinsically reinforcing. What this means operationally is not clear from the reports. Nor is it clear whether or not interest and motivation are operational synonyms. This reviewer feels they are probably not. Interest relates to a willingness, an eagerness to participate fully, actively, agressively, in an activity whether assigned or voluntarily selected. Motivation may be thought of as sustained interest confirmed by voluntary selection of one activity over others. Thus, one may have high interest in a given math activity but low motivation to elect math activities or studies over others to a degree above average.

It is believed that the reinforcement reported above, however defined, increases interest and motivation, however defined, and that these in turn, produce gains in achievement, especially in basic computational skills. While not always clearly stated in previous studies, these reported improvements in interest, motivation and achievement seem to be related to such factors as these:

1) Calculators give immediate feedback. With a programmed calculator the student knows immediately whether a response is correct or incorrect. A right answer is confirmed and reinforced. A wrong answer can immediately be replaced by other responses and is not negatively reinforced. With the regular four-function calculator

monotonous, time-consuming paper-pencil labor is removed. There is a shorter time lapse between idea formation and its confirmation or rejection.

2) Calculator use is concrete in a Piagetian sense. That is, it may be perceived by students to be more real, more trustworthy, than paper-pencil. (This probably contrasts with the beliefs of their elders). On a continuum (symbolic-pictorial-concrete) students may feel that calculator use is nearer concrete than is paper-pencil.

3) The calculator gives a fast link between prediction and confirming evidence. Everyone needs ways to check an answer. There are only three and calculators provide all. First, a problem situation may be replicated and this is quickly and easily done by self or peers. Secondly, a problem may be done by an alternative method, for example, addition to check subtraction. Thirdly, a proposed answer or solution may be checked with an expert. The calculator as expert substitutes for the teacher who may not be readily available.

4) Calculators are both personal and impersonal and in the right ways. If a student has his/her own calculator, it may be identified as "mine" and therefore friendly, dependable and helpful. On the other hand, it is an inanimate device, and while it "tells the truth" it does so in an non-judgmental way that is impersonal and non-threatening. This study was simple, straight forward and well-done. The conclusions reached seem valid and reliable and are not inconsistent with previous studies. It is reasonable to conclude that use of hand-held calculators has useful applications in teaching elementary school mathematics and may promote acquisition of basic computational skills.

The investigators' hypothesis that the use of the programmed feedback calculator would produce greater gains than use of the regular four-function calculator was not supported. Their hypothesis was based on the idea that the programmed calculator requires a mental calculation, or at least a mental guess, and that this apparently is a positive learning experience. They did not comment on this in their analysis. They did

speculate that the four-function calculator may be better because it provides a wider variety of exercises and allows drill on a single concept or skill until it is mastered. However, the Little Professor calculator used by this reviewer permits practice on one basic operation, and at several levels, indicating that it has an advantage included in the authors' original hypothesis.

It is likely that students do not perform mental calculations in using the programmed calculators. They merely guess and the rapid feedback without penalty may even encourage guessing. They merely select a possible answer. With the regular four-function calculator the operation must be "punched in" and this does require a mental operation coupled with the tactile sensation of the "punching." It is likely that the superiority of the four-function calculator is related to user control over the operation.

The "forgivingness" of the programmed calculator may be a weakness, not a strength.

A basic question not adequately addressed in this, and the studies cited, is the extent to which the ability to perform basic functions mentally, without aids, including paper-pencil, is essential, perhaps crucial. Everyone must have confidence in an answer and in its fit with real world conditions. An airplane pilot trusts the instruments used but not if what they tell is not confirmed by direct sensory observations. Similarly, the answer given by a calculator is to be trusted only so long as it works in the real world. And, in everyday life in the real world the calculator to be most trusted is one's own brain. Everyone must have ways to mentally estimate (ballpark) answers and to adjust them to needed levels of precision and to appropriate significant figures. An important question thus becomes, can calculators help, and how? Other related questions: Does calculator use promote their dependence? Is this good or bad? Studies of primitive cultures reveal the ability to perform remarkable feats we moderns would not attempt without the aid of mechanical devices. Navigation by ancient Polynesian sailors is an example. We must address the larger question of the appropriateness of a given technology.

There appears to be no definitive answer about whether calculator use enhances motivation. Apparently interest is high while they are being used and discipline problems decrease, but there is no clear evidence that sustained motivation is produced.

Also, predictions that long term increases in achievement can be obtained from calculator use must be cautiously made. In one study reported by the authors conventional methods were superior over time. And in the study reviewed here the conventional control group was not inferior to the programmed computer group at 15 weeks as they had been at 11 weeks. These results support comments made above regarding the essentiality of teaching mental skills.

In summary, this reviewer suggests that calculators be used, but cautiously and conservatively, and that research be continued based on the researchers' conclusion that basic design of the two types of calculators appears to have been more important than immediate feedback in determining differences between the two calculator groups. The technology of computers and calculators is advancing rapidly. It should be soon possible to construct programmed-feedback calculators with diagnostic capabilities. Such calculators would be far superior to the random algorithm type currently in use.

Volk, T. L. and H. R. Hungerford. "The Effects of Process Instruction on Problem Identification Skills in Environmental Education." Journal of Environmental Education, 12 (3): 36-40, 1981.

Descriptors--Cognitive Processes; *Environmental Education; Junior High School Students; *Problem Solving; *Process Education; *Secondary Education; *Skill Development; *Skills

Expanded abstract and analysis prepared especially for I.S.E. by Lowell J. Bethel, University of Texas-Austin.

Purpose

The purpose was to measure the effect of instruction on the problem identification skills of eighth-grade junior high students. The research question studied was: To what extent will an investigative skills environmental education (EE) program influence problem identification skills of eighth-grade junior high students compared to a traditional science program?

Rationale

Little emphasis is placed on the development of problem identification skills. This is an important skill in environmental education (EE) since there are many public problems requiring investigation. But little time is devoted in school curricula to the development of this skill.

Most science educators would agree that this skill precedes problem solving behavior. While much time has been devoted to problem-solving and its development, little attention has ever been focused on either the nature or development of this skill.

This is somewhat surprising since Dewey and Einstein identified this skill as critical to scientific inquiry many years ago.

Several sources are identified in the paper which refer to problem identification and its importance. Further, while there are many problem-solving or science inquiry models, none appears to exist for problem

identification. It is just possible that if one were developed, it would perhaps be helpful in the development of this skill. The authors go on to state that little or no research has been done in this area and therefore investigating the "effect of treatment on problem identification abilities" would be valuable.

Research Design and Procedure

A sample of 83 eighth-grade students in two classes was selected for the study. The students were from a middle to upper class Chicago suburb. One class was identified as the experimental group (N=43) and the other, the control group (N=40). The number of females was approximately half in each class.

The treatment used was a junior high school EE investigative skills development program during 1979. General science instruction from a typical science program was administered to the control group. The topic studied was meteorology. The experimental treatment consisted of six weeks instruction using the first three modules from an EE program entitled Investigation and Action Skills for Environmental Problem Solving. Instruction included defining environmental problems, classifying environmental issues, analysis of information sources, examining human values and issues, and collecting data from primary and secondary sources.

After six weeks both groups were tested using a paper and pencil phenomenological instrument. Subjects were first asked to list ten environmental problems, and, for each one listed, identification of two different positions on the issue. Finally, they were asked to identify the source of their knowledge concerning each issue listed.

The investigators employed a posttest-only control group design. Using a set of scoring instructions, a jury of three environmental educators randomly scored the test instruments (five from each group randomly selected). An interscorer reliability coefficient was calculated and found to be 0.917. These results confirmed the adequacy of the scoring criteria

and procedures. The investigators used standard means, deviations, and t-test of means on the data collected. Level of significance was not identified.

Findings

Experimental treatment group listed more issues, statement of sides of issue, and rationale for sides to the issue than did the control group. The difference was statistically different in all three instances at the 0.01 level or better. The experimental group listed significantly more sources for information than did the control group. Sources were rank ordered. For the experimental group the source most often cited was school while television was most often cited by the control group. The source least cited by the experimental group was parents while classmates was the least cited source for the control group.

Interpretations

It can be inferred that the treatment did significantly improve the problem identification skills of the experimental group when compared to the control group on the variables measured. All differences were significant at the 0.01 level at least. The standard deviations reveal less variation in the behavior of the experimental group. Thus the investigators hypothesize that at least one or more variables within the treatment promote problem identification skills in EE. However, what these are is not identified. Thus, further research is needed to factor out these variables that affect problem identification skills. The data also reveal that certain treatments (e.g., the science program used by the control group) do little to make students aware of important environmental issues.

ABSTRACTOR'S ANALYSIS

The study does not contribute to our understanding of how or what skills are employed for identifying environmental issues or problems.

The investgators do attempt to shed light on the skill of problem identification, but spend little or no time in analyzing its components or nature. They do not attempt to identify what variables are found in the treatment that affect problem identification development. Thus we are left just about where we started-at an attempt to uncover the nature of problem identification skills and their development.

An unfortunate aspect of the research design is that neither the treatment nor control group was pretested. It is possible that the pretest may have sensitized the groups, but no evidence is offered. Running a Solomon four-group design would have eliminated the problem and comparison could have determined pretesting effects.

The investigators do attempt to determine if both groups are comparable at the beginning because of the requirement to use intact classes. So they compared them on the basis of grade equivalent achievement test scores. No significant differences were found. However, it is difficult to then infer that they are equal in knowledge of environmental issues. But this is not of much help here with this problem. The investigators did note that they were unable to pretest the groups but no reason was given for this inability.

Although the investigators were conservative in their conclusions drawn from the findings, they suggested that science programs used are not effective in sensitizing students to environmental issues. Knowing the nature of many science programs and textbooks used, this suggestion is suspect. Since types of programs (and there was a significant difference in the nature of the ones used) were not really compared in terms of a common set of goals, it is therefore impossible to really arrive at this suggestion. It is an issue that should be investigated separately from the problem under study in this investigation.

It is possible that by working with a curriculum or science program that stresses environmental issues, students are sensitized to them. This needs to be investigated further. Another point to be asked is "is

problem identification of environmental issues different from, say, problems in biological or physical science?" If it is not different, then students should be able to identify problems no matter the field or milieu. This will need to be examined closely under controlled conditions.

The subject is an important one for science education. Results of the investigation need to be examined carefully and further testing undertaken. It is a very important skill when attempting to introduce scientific inquiry or problem-solving. It is hoped that the investigators will continue to investigate this important science skill.

Lawson, Anton E. and Warren T. Wollman. "Developmental Level and Learning to Solve Problems of Proportionality in the Classroom." School Science and Mathematics, 80 (1): 69-75, Jan. 1980.

Descriptors--Concept Formation; *Cognitive Development; *Edicational Research; Mathematics Instruction; *Ratios (Mathematics); Secondary Education; *Secondary School Mathematics

Expanded abstract and analysis prepared especially for I.S.E. by Richard M. Schlenker, Maine Maritime Academy.

Purpose

The authors of this study attempted to evaluate the hypothesis that the development of Piagetian formal operations must precede instruction dealing with proportions if such instruction is to be beneficial to more than just a few students.

Research Design and Procedure

To test the hypothesis, 28 grade seven students, with a mean group age of 12.8 years, were pretested, categorized as early concrete operational, late concrete operational, or early formal operational; trained; and posttested. Pretesting involved administration of Conservation of Weight (Elkind, 1961), Conservation of Volume (Elkind, 1961) and, Volume Displacement (Karplus and Lavatelli, 1969) while posttesting included administration of the Balance Beam (Inhelder and Piaget, 1958), the Discs, the Math Quiz (Sheehan, 1970), Mr. Tall and Mr. Short (Karplus, Karplus and Wollman, 1974) and, the Machine Problems. All instruments have been previously well described in the literature and, therefore, need not be further described here.

During the training phase of the investigation, subjects were taught to solve proportionality problems in a manner consistent with Dolciani, Wooton, Beckenbach and Chinn (1967). Subjects, during the training, dealt specifically with ratio and proportion, ratio and percent, percents and percentages, and percents in banking and buying.

Findings

Subjects were categorized as: early concrete operational, late concrete operational, and early formal operational. Pretest, posttest statistical comparison when evaluated with training as a constant showed the early concrete group lacked the ability to use proportions. Late concrete operational subjects had limited success with the application of proportional logic while the early formal group was generally successful.

ABSTRACTOR'S ANALYSIS

The investigators mention a possible weakness in experimental design; that the reliability of the pretest with only three items is not large. We are left to question whether the pretest reliability was computed and, if so, what the value was.

The investigators further suggest that even though the reliability is low, teachers could use a few of these instruments to obtain initial information about students' reasoning abilities. A question must be raised as to why such guidance is given to teachers if there is some reasonable probability that the results they obtain may have little meaning. Can it truly be said, instruments of low reliability will identify students who might manifest problems understanding the difficult aspects of instruction? Although such points are discussed, they seem not to be supported by evidence.

The sample size, category sizes, and source limit the generalizability of the results. First, four students were classified as early concrete, eight as late concrete, and sixteen as early formal. Even though the manner in which the groups responded to all posttest items except Mr. Tall and Mr. Short (Karplus, Karplus and Wollman, 1974) was statistically significant and responses on this item across the groups of students were positive but not statistically significant, what do these findings really mean? Before teachers can be expected to use the guidance provided by the authors, there must be stronger evidence that, when applied to another

group of students - perhaps from a different geographical area, socio-economic strata, or some combination thereof, this method of evaluation will yield meaningful results. While the results of this study lend support to the Piagetian hypothesis, that in itself is not sufficient reason why classroom teachers should spend valuable class time using these instruments to evaluate their students. The study should be reported using larger samples. Samples should be selected for inclusion in the study based upon some scheme which considered children from a variety of different types of communities. Again, it cannot automatically be assumed because the results of this study reflect abilities of students from an upper-middle class community that students from less fortunate communities will necessarily be less formally-oriented.

As the authors point out, students do vary widely in intellectual level, a fact which may indeed be the reason why some manifest low comprehension of material being taught while others respond in a converse manner. We must, however, question why perhaps the single most important instructional variable is not considered; that variable is the teacher. Why is it that some students do extremely well with specific concepts, while similarly aged students of similar backgrounds fail on a relative basis, when the only difference they experience is the teacher? The teacher is a more important instruction variable than the developmental levels of students. Instructor characteristics need to be compared with student success based upon students' intellectual levels.

As the authors mention, a major research effort is needed to determine how students acquire mathematical concepts.

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Descriptors--*Academic Achievement; Biology; *College Science; Higher Education; *Individual Differences; *Individualized Instruction; Science Education; *Science Instruction

Expanded abstract and analysis prepared especially for I.S.E by Linda R. DeTure, Rollins College.

Purpose

The purpose of this study was to determine and predict the relationship between achievement and success within the audiotutorial (AT) method of instruction and personal characteristics. The three central questions asked were: (a) Do significant relationships exist between personal traits and achievement and success (dependent variables)? (b) Do high achievers and low achievers have different sets of personal characteristics from students who are low or high on both achievement and attitude? (c) Does the battery make reasonable ex post facto predictions?

Rationale

This study seeks to add to and refine the body of knowledge related to the success of students in the AT approach to individualized instruction. The differential effects of instruction are examined because the identification of trait-treatment interaction is viewed as a prerequisite to prescriptive instruction. Prior AT research results which provided direction to the study include the following: math aptitude has been the best predictor of achievement; personality factors have small but positive correlations with achievement; females usually have higher achievement than males; and attitude toward science is significantly related to achievement.

Research Design and Procedure

Data were collected during the latter part of a second semester, year-long introductory biology course. The sample, consisting of 119 of the 158 students enrolled, was slightly skewed toward high achievers.

The investigators utilized a one-shot case study, preexperimental design. The battery of tests used to gain information on 18 personal traits included the Scholastic Achievement Test (SAT), the Guilford-Zimmerman Temperment Survey (GZTS), Moore's Scientific Attitude Inventory (SAI), the Nelson Biology Test (NBT) and an attitude toward instructional mode designed by the researchers. Content validity and reliability were determined for all measures.

High and low achievers were defined as the upper and lower quartile scorers on the NBT. To be placed in the "success group," students had to score in the top third on both the achievement and attitude toward AT instruction. The "unsuccessful" group scored in the bottom third for both groups.

The researchers examined the relationship between achievement and battery of predictors using multiple regression analysis. Discriminant analysis contrasted the factors identified for high and low achievement and success group.

Findings

With all factors considered, 23.3 percent of the variance in raw achievement scores was explained. As anticipated the SAT math aptitude, which accounted for 9.8 percent of the variance, was the highest correlate. The important personality variables were restraint and masculinity. With these variables entered in the step-wise multiple regression, 15.1 percent of the variance was accounted for. When aptitude was removed from the equation, masculinity, restraint, gender and general activity explained 13.2 percent of the residual variance.

In two group step-wise discrimination analyses, significant differences were found between the mean sectors on each criterion. For ten achievement and success groups, the SAT verbal and math scores, respectively,

were the most significant predictors. While aptitude was the main function for differentiation, personality and instruction attitude were additional points of contrast. When both achievement and attitude were used as criteria, aptitude was still the principal discriminator. Attitude toward science, the most important secondary factor, appeared to be a measure of attitude toward the instructional mode.

Comparisons between ex post facto predictions and observations were better for low group membership than for high. Ninety-four percent of the low achievers were correctly classified while only about 50% of the high achievers were. Overall 70 percent were properly classified. The factors associated with lack of success appear to be more predictive than those associated with higher success.

Interpretations

The results of the study explain small but significant amounts of variance for achievement with the SAT math being the highest correlate. The researchers concluded that ex post facto classifications were better for low groups than high. SAT scores and attitude toward science were the most discriminating indices. The student's attitude toward the instructional mode had little relationship to achievement, except for a small group of students who were incompatible with the AT mode of instruction. Trait treatment interaction is suggested as a means of determining which students would function better in alternate forms of instruction.

ABSTRACTOR'S ANALYSIS

This research adds to the growing number of studies examining the parameters of audiotutorial instruction. The ex post facto analysis allows the researchers to examine the interaction of student traits with the treatment which in this study is the audiotutorial instruction mode. Although this is not intended to be an ATI (Aptitude Treatment Interaction) study, it does provide information that might serve as a conceptual foundation for future ATI research. Within the given treatment framework (AT)

the authors make a laudable effort to systematically determine which student traits influence performance for this particular instructional mode.

By utilizing the ex post facto design, the researchers were able to capitalize on previous AT research when selecting the traits to serve as correlates. Despite the general controversy centered around using SAT scores as predictors of success, this variable repeatedly pops up as the highest correlate when achievement is being scrutinized. The SAT math, if it can be construed as a measure of abstract reasoning, seems to be a good predictor of success for biology. The other student characteristics, which were supported in earlier research, had lesser impact on achievement than was expected. Both personality and attitude exhibited small, but positive relationships.

The selected statistical tests were appropriate and necessary for a first order probing of the one-shot case study, preexperimental design. Multiple regression analysis was used to examine achievement and the battery of predictors. In the report the author did not decribe or list the specific dependent variables used in the analysis. Information on 18 personal traits was collected using five different instruments. The question is raised as to whether the researchers regressed achievement on all 18 traits or on composite scores from each test. From the information contained in the tables and report it is impossible to determine. As an example, both the SAT verbal and math scores were used because each contributed to achievement and was listed in the Summary of Achievement Regression Analysis Table. Others listed, but not identified, were restraint, masculinity, gender, general activity. How is the reader to know what "general activity" measures without having access to the battery of tests, which may not be readily available, or for the author to identify it? The omission of this kind of information and operational definitions makes it difficult to interpret the results. One has to rely largely on the authors' stated findings, interpretations, and conclusions.

Another problem that concerned me as a reader of a research report was lack of any real sample numbers attached to the tables. Only summary statistics were reported for any of the analyses. Data were collected from 119 of 158 potential subjects and the researcher reported that the sample was skewed toward high achievers, but no actual numbers were reported. The reader has to speculate the effect those 39 missing subjects might have on the sample distribution. The results for student classification by discriminant function is given only in percentages. Real data reported by percentages can easily be misleading and misinterpreted. For example, 50 percent of 2 is very different from 50 percent of 100. From the information provided there is no means for the readers to either refute or offer alternative interpretations from the researcher.

These concerns illustrate a weakness in the reporting of research studies. What appears to have been a thorough analysis of an interesting research question is undermined by, perhaps inadvertent, omissions in both the report and tables. Too many assumptions have to be made between what the reader surmises and what the researcher reported.

Despite the comments regarding the report, the study adds to and supports the matrix of research related to achievement and instruction in biology, particularly to the AT mode. The notion that low aptitude scores predict low achievement more reliably than do high scores, high achievement is an important contribution that designers of instruction need to know. This finding alone suggests several directions which future research may take. Matching learning style with instruction mode is a fertile area. If low success students can be reliably identified, as suggested in this study, alternative instructional strategies can be designed, developed and tested by experimentally designed research.

This study adds support data to the idea no one model of instruction, even if it is quasi-individualized, is equally suitable for all types of students. Perhaps the most important contribution of this study is that it moves us, as science educators, forward in the search for a theory of instruction.

Enyeart, Morris A., Dale Baker and Dave Van Harlingen. "Correlation of Inductive and Deductive Logical Reasoning to College Physics Achievement." Journal of Research in Science Teaching, 17 (3): 263-267, 1981.

Descriptors--*Academic Achievement; *College Science; *Deduction; Educational Research; Higher Education; *Induction; *Logical Thinking; Physics; Science Education

Expanded abstract and analysis prepared especially for I.S.E. by Ubiratan D'Ambrosio, Interdisciplinary Center for the Improvement of Science Education (CIMEC/UNICAMP), Brazil.

Purpose

The study was done in order "to determine whether both the inductive and deductive components of logical reasoning contribute equally to achievement in an introductory college physics course".

Rationale

The authors separate logic reasoning into deductive and inductive components, both contributing to build-up a cognitive ability which, combined with several other factors, determines achievement in college physics. Motivated by the fact most of the known research in this field aims at examining either deductive or inductive components of logical reasoning as independent variables which influence the acquisition of scientific concepts, the authors aim at determining the relative contributions of these types of logic reasoning to science achievement in schools.

Research Design and Procedure

In order to do this, the authors identify performance on tests requiring inductive or deductive logical reasoning as the independent variable and achievement, as measured by course grade, as the dependent variable.

They selected thirty male and female students enrolled in a university-level, introductory physics course as subjects. The subjects participated

voluntarily in the study. The mean age was 20.75 years.

A pretest was applied to all the subjects in three consecutive sessions during the first week of the term. Subjects were divided into three groups (alphabetical order) and each group received six tests. There were no special instructions to the subjects and, indeed, instruction provided was typical of an introductory college physics course, with typical testing (quizzes, midterm and final exams).

The six tests administered measured specific types of logical reasoning, with three tasks measuring deductive logical ability and another three measuring inductive logical ability.

The tests utilized were, respectively, Propositional Logic Tests, the Turtles Task, Diagramming Relationships, Letter Sets, Figure Classification and Verbal Analogies.

Scoring was according to Elementary Testing Science Factor-Referenced Test Kit.

Findings

The results are presented in the form of two tables; Table I: Test Means Standard Deviations and Logical Structures, and Table II: Correlation Coefficients Between Tests and Final Grade.

Noticeable are the results concerning Verbal Analogies, which has two subtests: VBA 1 (utilizes a multiple-choice format with formal, nondegenerate analogies) and VBA 2 (consists of paragraph analogies taken verbatim from the course text). A high mean of VBA 1 indicates the majority of the sample did possess analogical reasoning ability, VBA 2 suggests subjects were unable to successfully apply that ability to passages from their text. VBA 1 and VBA 2 were the only exceptions to measures which have significant correlations with final grade. Tests of deductive logic (Diagramming Relationship and Propositional Logic

Test) correlate most highly with final grade at approximately equal levels. The following conclusions are noteworthy:

1. Significant correlations between final grade and both inductive and deductive logic measures indicate that several logical abilities are important for success in an introductory physics course.

2. From the pattern of correlation coefficients between tests and final grades, we may conclude that deductive logical ability contributes more to achievement in an introductory physics course than does inductive logical ability.

Interpretations

The results of the study suggest that the various components of logical reasoning do not contribute equally to achievement in an introductory college physics course. Most of instruction is in the deductive style and the students are involved in testing hypothesis and postulates, not formulating them. Therefore, the form of logic most used is deductive logic.

Even the analogies in a physics test do not correlate with achievement, which may be explained by the fact that these analogies are used to introduce or explain a previously formulated hypothesis, which is a deductive process. But this is going against the concept of analogy as an inductive process. A more appropriate use of analogies suggested by the authors is to present them to students as a tool to facilitate formulation of hypotheses, and afterwards going to deductive processes. The authors suggest a better combination of inductive and deductive logical reasoning in physics courses.

ABSTRACTOR'S ANALYSIS

As the authors have commented, research results are known in either

deductive or inductive logical reasoning as related to course achievement, but there is a lack of research on the combined strategy of both processes. Future research might go in the direction of examining the interrelationship of inductive and deductive logical reasoning in building up cognitive abilities and the influence of this interrelationship on science achievement. It is not easy to separate general abilities into components and to study their interrelationships, but surely it is worthwhile trying.

As the authors have commented, motivation to achieve the highest possible grade among the subjects was especially influential for their future careers (entrance to a post-graduate medical school), which may limit the generalization of the study to other populations.

Douglass, Claudia, Jane B. Kahle and Janet S. Everhart. "Interracial Behavior Patterns in an Inner City Biology Laboratory." School Science and Mathematics, 80 (5): 413-422, May-June, 1980.

Descriptors--Biology; Disadvantaged Youth; *Educational Research; *Inner City; Policy Formation; *Racial Relations; *School Policy; Science Education; Secondary Education; Secondary School Science; *Urban Education

Expanded abstract and analysis prepared especially for I.S.E. by Ronald D. Simpson, University of Georgia.

Purpose

The purpose of this study included three facets: (1) to assess the nature of interracial interactions within a disadvantaged, inner city high school, (2) to identify what factors predict these interactions, and (3) to suggest what implications such interactions should have on the policies and strategies of the school.

Rationale

The investigators began this report by focusing on differences in achievement between disadvantaged and middle class students. They pointed out that academic attainment, particularly for disadvantaged students can be predicted by school environment, student body, social composition, and student interactions. They also pointed out that, based on other research, school budgets and facilities are less important than the aforementioned variables. Given the selected socio-economic variables are important factors associated with the successful education of disadvantaged youth, the investigators build a case for the importance of this kind of research.

Research Design and Procedure

A total of 72 subjects participated in this study. They were from a large urban Chicago high school. Most were Black students from lower socio-economic backgrounds in their sophomore year. The students were all enrolled in a required course to which they were randomly assigned by computerized scheduling.

A 37-item survey instrument based on a questionnaire developed by Patchen and Davison was administered to each student. The items were categorized into three groups: (1) biographical data, (2) friendly, unfriendly, and avoidance behaviors experienced between races, and (3) personal, family, and neighborhood characteristics and interracial attitudes. The authors stated that "the impact of past experiences on current attitudes and behaviors was assessed through the variables grouped as family and neighborhood background. Variables grouped as other races allowed the evaluation of the impact of emotions on interpersonal relationships. And finally, the extent to which the amount and nature of interracial contact was a function of the opportunities for contact in the school setting was assessed by the remaining variables." The instrument was administered simultaneously by the three classroom teachers serving as instructors to the subjects. Measures were taken to insure privacy and anonymity. Students were encouraged to be honest and candid.

Findings

Two questions guided the analysis of the data: (1) what is the nature of interracial interactions in an inner city high school; and (2) can predictors of these behaviors be established? The results included an initial assessment of the criterion behaviors, a correlation between the criterion behaviors and the predictor behaviors.

The three behaviors, friendly, and unfriendly interracial contacts, and avoidance behavior were analyzed by the three categories. The Likert-type scaling procedures produced the following results by the authors in Table 2 of their paper:

Ranking According to Friendly Interracial Contacts,
Unfriendly Interracial Contacts, and Avoidance Behavior

RACE	N	Friendly[a]	Unfriendly[b]	Avoidance[c]
Black	57	6.89	4.00	1.96
Latino	5	8.60	3.60	.80
White	3	7.67	3.33	.67

a Higher score indicates more friendly interracial contacts.
b Higher score indicates more unfriendly interracial contacts.
c Higher score indicates greater avoidance behavior.

The investigators then calculated correction coefficients for the three criterion behaviors and the sixteen predictor variables. They then produced a stepwise multiple regression for the four sets of grouped independent variables that were used to predict each of the three criterion behaviors.

Opportunities for and the nature of contacts with other races accounted for 25 percent of the variance of friendly interracial contacts. The remaining three groups of predictors collectively accounted for an additional 16 percent of the variance of friendly contacts between races. Perceptions and attitudes accounted for seven percent of the ability to predict the criterion behavior. Family and neighborhood backgrounds accounted for five percent of the variance while personal characteristics increased the prediction by four percent.

One's opportunity for and the nature of contacts with other races accounted for 43 percent of the variance of unfriendly interracial contacts. Family and neighborhood background accounted for 10 percent of this variance; perceptions, and attitudes toward other races, four percent; and personal characteristics, two percent.

Variables grouped as opportunities for and nature of contacts with other races were also the best predictors of avoidance behavior, accounting

for 32 percent of the variance. Personal characteristics of students accounted for an additional 21 percent. Family and neighborhood along with individual perceptions and attitudes toward other races accounted for an additional 11 percent of the total variance.

Interpretations

In this study, Latino and White students reported the most friendly interracial contacts and the least avoidance behaviors. Black students reported the least friendly interracial contacts and the most avoidance of students of other races. The investigators pointed out that since White and Latino students were in the minority (12 percent) in this group, they may have found a greater need to exhibit friendly behavior.

Based on correlational data, several factors appeared to be related to friendly interracial behavior patterns. The more satisfied individuals felt toward their life circumstances, the more friendly they were toward students of other races. One result was surprising: The more negative the family attitude toward another race was, the more friendly the contacts of the student were toward that race. The more opportunities for inclass contact that existed, the more friendly interracial contacts were. The investigators concluded that by providing positive reinforcement, developing positive attitudes, and by fostering positive self-concept, friendly classroom contact between students of various races can be facilitated.

The investigators also concluded: "Unfriendly interracial contacts were most significantly related to the anger a student felt toward other race students and to the unfriendly interactions a student had with people of his same race. In general, unfriendly interracial interactions tended to be related to personal discontent. Avoidance behaviors were inversely related to the satisfaction one felt with his life and to the degreee of conformity he showed to school norms. The more that a student felt that reaching his goals was facilitated by someone of another race, the less he tended to avoid people of another race. Also, the more unfriendly interactions a student had with people of his own race, the less avoidance

behaviors he showed toward other races. however, less avoidance of other race students was shown by students who feared them the most. Therefore, to curtail avoidance behaviors in the classroom, one might encourage interracial groups to work together to reach common goals. The variable grouping which predicted the likelihood of friendly interracial contacts the best was opportunities for and nature of contacts with other races which accounted for 25 percent of the variance. Once again it was shown that the opportunity for and nature of contacts with other race students both in the classroom and around the school influenced the amount of friendly interracial contacts a student had."

Unfriendly interracial contacts were related most closely to the nature of contacts with other races (43 percent of variance) and family and neighborhood background (10 percent). The investigators concluded here that to reduce the number of unfriendly interracial contacts between students in the classroom, the amount of anger felt between the two groups needs to be reduced. Also, when security from their own race was felt, they showed more unfriendly behavior patterns toward other races.

Opportunities for and the nature of contacts with other races was found to be the best predictor of avoidance behavior. The more unfriendly interactions students had with members of the same race, the fewer avoidance behaviors they showed toward students of other races. The researchers concluded that to reduce avoidance behavior students need to experience a feeling of satisfaction with their own lives.

ABSTRACTOR'S ANALYSIS

The investigators in this study found that variables grouped as opportunity for and nature of contact with other races accounted for the greatest amount of variance within all three criterion behaviors. Of the four variables composing that grouping, satisfaction with the circumstance of one's life was associated most strongly with both friendly and avoidance behaviors. At this point, the investigators chose to imply that "being satisfied with one's life" influences the way in which an

individual reacts to members of another race. As the opportunity for inclass contacts increased so did the amount of friendly interracial contacts. It is interesting to note that opportunities for around school contact did not correlate inversely with avoidance behaviors. Strongly implied is the notion that the classroom is the best place to build cooperative relationships. In other words, the investigators finally concluded that teachers may foster friendly interracial behaviors by positively reinforcing students' in-class contacts with other races. In this study positive interracial attitudes correlated directly with positive self-attitudes and positive attitudes toward peers. The investigators suggest the use of instructional strategies and school policies which maximize opportunities for interracial contact within the classroom. They suggest that this may also serve to minimize potentially troublesome large group encounters outside the classroom, improve interracial behaviors, and possible increase academic performance.

I consider the topic addressed in this study a very important one. Science educators have a responsibility to present their discipline to students of all races in a manner that will maximize commitment and achievement. In the past most minority groups have been underrepresented in science. This investigation sheds light on important psycho-social variables that relate indirectly if not directly to achievement in science among minority students.

The essence of this report suggests that by allowing for positive interracial contacts in the classroom, more positive attitudes toward members of other races can likely be achieved. Associated with this relationship was the finding that those who were the most satisfied with the circumstances of their life were also the individuals experiencing the most interracial harmony and the least avoidance behavior. As stated earlier, self-satisfaction along with opportunities for inclass contact were the most clearly related to positive interracial activities.

I, therefore, think that the direction of this research possesses promise. The results give us some strong hints relative to future direc-

tions in which both research and practice should head. I have three suggestions for strengthening other investigations that need to follow. First, more information needs to be provided relative to the survey instrument used in this study. The instrument is apparently an unpublished scale and as an investigator in the field of science attitudes, I found this report lacking standard information. For me, this aspect of the study was reported in too arbitrary and incomplete a fashion.

Second, I would strongly recommend that this study be repeated with a larger sample, involving more teachers, more schools and a more balanced mix of ethnic and socioeconomic groups. The investigators in this study acknowledged this in their report. The number of Latino and White students in this study basically nullifies any cross cultural comparison.

Third, I would offer a cautionary note for interpretation associated with this study and other studies of this type. While high positive correlations depict strong relationships and suggest causality, we must discipline ourselves in this kind of exploratory research to refrain from making claims that imply too strongly that cause and effect exists. The design and subsequent implementation of this investigation places support for cause and effect on shaky ground. While it certainly appears logical that increases in inclass contact between races produces positive interracial attitudes and behavior, this single study represents an inadequate base on which to make such claims. Though these two variables correlated highly with each other, it is possible, in fact, that they were actually being influenced in the same direction by other variables. Those of us who rely on inferential statistics as a basic tool need to work prudently and patiently with our causal modeling. Fortunately, there are new mathematical and statistical tools, such as LISREL, available today that help us construct more accurate explanations.

This research study addresses an important issue and is one that should be repeated. In the meantime, I accept as highly plausible the conclusions of the investigators. There is strong evidence that the classroom serves as a powerful influence on educational and social outcomes. It appears

to me that the science teacher who is concerned about multicultural education is in a position to exert leadership and influence through the use of selected instructional strategies. I trust that this relevant investigation will serve to stimulate other studies of this kind.

RESPONSES TO CRITIQUES

IN RESPONSE TO THE ANALYSIS OF

McDuffie, Thomas E. and Matthew H. Bruce. "Predicting Achievement and Success in an AT Biology Program" by Linda R. DeTure. Investigations in Science Education, 17 (5): 449-454, 1980.

Thomas E. McDuffie, Jr.
Saint Joseph University

Relative to the critique of the article which I co-authored with Dr. Matthew H. Bruce, "Predicting Achievement and Success in an AT Biology Course," I found the abstract and observations most interesting and helpful.

Of all the comments made, positive and negative, the one that both could and should have been corrected relates to the presentation of data by percentages. In the future, I can assure you that I will be more cautious. At one point both the percentages and numbers were included as were a number of other tables, and explanations of different traits. The dictates of space were such that much of the information Dr. DeTure correctly cited as missing had to be deleted to meet the space limitations mandated by the journal in which the article was published.

One area that was not commented about and upon which I would welcome comments is writing style. All too often, articles I have read, reviewed, or edited seem to be pasted together rather than flow from one point to the next. A major effort during the past several years has been to improve my ability to communicate. Thus, any comments to be shared would be most welcome.

I appreciate the reviewer's comments and find them both perceptive and kind.

IN RESPONSE TO THE ANALYSIS OF

Volk, Trudi L. and Harold R. Hungerford. "The Effects of Process Instruction on Problem Identification Skills in Environmental Education" by Lowell J. Bethel. Investigations in Science Education, 12 (3): 36-40, 1981.

T. L. Volk
Murray State University

H. R. Hungerford
Southern Illinois University-Carbondale

The writers appreciate the opportunity to react to Dr. Bethel's abstract and research critique published in this issue of Investigations in Science Education. It is unfortunate that this reaction is necessary since neither writer, due to current commitments, has readily available time or energy to expend toward such an effort. Also unfortunate is the process used in the selection of research to be critiqued by the reviewers, the sometimes inadequate abstracting, and the "hammer syndrome" accompanying the entire process - a phenomenon that is not constructive nor conducive to the improvement of research in areas where more competent research is desperately needed. However, the writers feel obligated to write a response which corrects the inadequate abstracting of Dr. Bethel, which corrects errors in the critique, and which, hopefully, will permit the reader to separate fact from fiction.

Dr. Bethel's very first paragraph in the critique is, in fact, spurious. Several comments by the writers are offered in rebuttal: (1) His statement that the study does not contribute to an understanding of how or what skills are employed for identifying environmental issues or problems is marginally correct. However, this was not the intent of the research. The research was simply directed at determining whether a particular treatment would, in fact, contribute to an increased ability to identify problems in the environmental arena. (2) The comment that the writers did not attempt to identify the variable found in the treatment that affected problem identification is, again, marginally correct. If Dr. Bethel was referring to the exact, precise components of problem identification, he

is absolutely on target. Again, however, this was not the intent of the research. The writers did, in fact, summarize the major instructional components hypothesized to contribute to the student's ability to identify problems in environmental education. Dr. Bethel did include this information in his abstract and, therefore, the writers do not understand the source of his comment unless he is critical of the precision with which the writers identified variables associated with the development of problem identification skills. (3) His very last sentence in paragraph one suggests that the research went nowhere - that the researchers were trying to uncover the nature of problem identification skills and did not do this. Nowhere did the writers establish the point that this was a major agenda in the research - particularly, when far more competent researchers in this area have pointed out how extremely difficult it is to do what Dr. Bethel criticizes the writers for not doing. (4) In summary, the writers were simply attempting to determine the extent to which a problem investigation skill development model would influence problem identification skills. This was clearly stated in the purpose statement of the original article.

Although Dr. Bethel's bias toward "running a Solomon four-group design" is agreed to by the writers, paragraph two of the critique is a real problem - for part of which the writers must assume fault. Using a Solomon four-group design in this instance was impossible since four groups were not available to the researchers (and the writers did fail to report this fact). However, a post-only control-group design does have empirical merit, and is recommended by Campbell and Stanley (1963) "in education research . . . (where) we must frequently experiment with methods for the initial introduction of entirely new subject matter, for which pretests in the ordinary sense are impossible" (p. 25).

The researchers were also criticized for not pretesting the groups, although Dr. Bethel did note that a pretest might have sensitized the groups. This is precisely what the researchers were trying to avoid. Pretest sensitization is an enemy of the behavioral empiricist and Dr. Bethel should understand this. Further, there was no need to pretest

since subjects were randomly assigned to the groups (something which Dr. Bethel omitted from his abstract).

Dr. Bethel seems further confused as to why the researchers chose to measure the comparability of the groups by equating them on achievement test scores. Kerlinger (1973), for example, promotes the advisability of equating groups irrespective of random assignment. The writers felt that random assignment by the school administration might leave some margin for error in distributing equally the variance within the groups, and decided to use one more device to measure the extent to which the groups were equal. This was pointed out in the original article, but ignored by Dr. Bethel in his abstract and in his critique.

The writers must now confess to a considerable amount of irritation on their part toward the manner in which Dr. Bethel dealt with the research findings. In order to provide the reader with a knowledge base, the concluding paragraph is quoted from the original article (numerals in brackets have been added for reference).

> In conclusion, it may be inferred that the treatment in question did, in fact, result in a number of important outcomes. [1] Students experiencing the (investigative skills program) could identify a greater number of issues, [2] could identify a greater number of positions associated with these issues, and [3] could state a greater number of position rationales than could students receiving the control treatment. [4] Further, data definitely indicate that the school can be a powerful force in proving a scenario within which problem identification skills can develop [5] Unfortunately-the data also suggest that certain treatments (e.g., the control treatment as defined herein) are only minimally effective with respect to making adolescents aware of critical issues within the environment. (Volk and Hungerford, 1981, P.39).

We wish to make several points about these statements. Once again, the purpose of the investigation was to measure the effect of process instruction on the problem identification skills of eighth grade students. The traditional science program treatment was chosen for comparison purposes only to enable the researchers to measure the relative effects of the two divergent treatments on the dependent variable. Thus, we feel quite comfortable with the first four inferences stated above. It seems that Dr. Bethel short shrifted these findings in his abstract and overlooked them completely in his critique. Instead, Dr. Bethel's critique focused only our fifth inference[5]. Given that our control treatment consisted of a typical science program, we feel that the data also support this inference, and invite readers to consult the original article and to draw their own conclusions.

The writers are criticized for suggesting that typical science programs are not effective in sensitizing students to environmental issues. Dr. Bethel cites "the nature of many science programs and textbooks used" as the basis for his exception to our suggestion. We agree that there is tremendous variability in science program. Even so, forty-six (46) cumulative years in education and interactions with numerous science programs have permitted the writers this inference. Additionally, in the interim between the preparation of the original article and 1984, the findings of Project Synthesis (Harms and Yager, 1981) have strengthened the case for this inference. Science education does not deal effectively with science-related societal issues. Dr. bethel's argument that this issue should be investigated separately is most certainly, today, a moot issue - unless, of course, he takes exception to the findings of Project Synthesis.

The writers would have like to have seen a bit more acceptance of their research by the reviewer. Of course, there are no ethical or professional demands for soft-stroking by research evaluators. However, there are ethical parameters associated with the abstracting process and with the interpretation of empirical evidence, irrespective of the personal biases of the reviewer. In the latter two instances, these ethics appear

to have been stretched a bit, if not violated substantially. This is extremely unfortunate since his criticisms place the writers in an adversary relationship with Dr. Bethel - one which they loathe.

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